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New Missions Enabled by New Propulsion Technology and Systems (9)

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# ENABLING INTERPLANETARY EXPLORATION FOR CUBESATS WITH A FULLY CHEMICAL PROPULSION SYSTEM

**Abstract**

Interplanetary CubeSat missions are recently becoming more popular, with a significant number of new missions currently ongoing or planned, thanks to their potential to enable low-cost exploration with good scientific goals. In these missions, the availability of a primary propulsion system capable of meeting all mission requirements becomes crucial. The context is a Mars mission starting from a parking orbit around Earth. Chemical propulsion systems are characterized by high thrust levels, allowing for fast Earth escape and Mars stabilization manoeuvres, and reducing the transfer time. The adoption of a chemical propulsion system for the Earth-Mars transfer phase is investigated, considering the recent developments of chemical propulsion systems for CubeSats. A preliminary mission analysis is performed considering the performance parameters of state-of-the-art CubeSat chemical propulsion systems. The total $\Delta V$ budget required by the mission is estimated, finding an optimal value of thrust level and propulsion system burn time for each manoeuvre. A trade-off of propulsion system type and propellant, based on performance, heritage and toxicity of the propellant, results in the adoption of a mono-propulsion system using the HAN-based propellant AF-M315E (ASCENT). The main challenge for the propulsion system is to fit inside a CubeSat standardized volume, which can range up to 24 U: several pressurization options are investigated, and the implementation of a micro pump is considered, choosing a suitable COTS component that fits the mass flow and pressure requirements of the system. The complete architecture and design of the propulsion system is presented: five 1.2 N thrusters are custom designed to produce up to 6 N of total thrust, demonstrating the feasibility of the mission for a 24 U CubeSat mostly adopting COTS components for the feed system. Considering an initial spacecraft mass of 28 kg, the propulsion system leaves 10.3 kg and 3U available for all other subsystems and payload. A peak power of 83 W when thrusting is estimated, lower than electric propulsion system counterparts, while the transfer time is reduced to be less than 1 year. This work demonstrates the feasibility of adopting full chemical propulsion for an interplanetary CubeSat mission, with consequent advantages in terms of transfer time and required power, at the cost of relatively small mass and volume left for the other subsystems. Even better results can be expected for interplanetary missions requiring slightly lower $\Delta V$ budgets, such as Near Earth Objects exploration or asteroid flyby missions.